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אני, (שם המבקש, מענו – ולגבי גוף מאוגד – מקום התאגדותו)
I (Name and address of applicant, and, in case of body corporate-place of incorporation)

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Owner, by virtue of of an invention, the title of which is

(בעברית)
(Hebrew)

"MULTIPOINT DIGITAL SUBSCRIBER LINE WITH HOME DATA NETWORK ABILTY AND METHOD THEREFORE."

(באנגלית)
(English)

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MULTIPIONT DIGITAL SUBSCRIBER LINE WITH HOME DATA NETWORK ABILITY (NDSL) AND METHOD THEREFORE

מערכת תקשורת דיגיטלית רב נקודתית למנויים עם יכולת מימוש של רשת ביתית ושיטות נוספות.

ABSTRACT

1. A multipoint digital subscriber line communication system with home network ability (NDSL) comprises a xDSL office modem placed at CO and connected by twisted pair of telephone cable to subscriber premise, and number of NDSL (Network DSL) modems placed at subscriber premise and directly connected to said twisted pair. Each NDSL modem comprises upstream transmitter and downstream receiver those are using for communication with CO , and upstream receiver that is using for communication with others NDSL modems, placed at the same subscriber premise. A communication between NDSL modems placed at the subscriber premise is realized in half-duplex mode with TDM method. Only ADSL and (or) VDSL upstream frequency bands are using for communication inside subscriber premise.

FIELD OF THE INVENTION

The present invention relates generally to data and voice communications over digital subscriber lines placed on twisted pair telephone cable and, more particularly, to a method and apparatus for multipoint communication in a splitterless asymmetrical digital subscriber line (ADSL) system.

BACKGROUND OF THE INVENTION

Digital Subscriber Line is a new communication technology that allows existing twisted pair Cable Telephone Network to be converted into a high-performance Multimedia Digital Network for multimedia and high-speed data communications with ability provide to every subscriber high speed data communication that include many new services as Video on demand , Conference VideoPhone, HDTV Broadcast , Digital Hi Fi Audio , Fast Internet and e.g.

Digital Subscriber Line technology includes several types of xDSL system differences by downstream and upstreem data bit rate : Symmetrical Digital Subscriber Line (SDSL), Asymmetrical Digital Subscriber Line (ADSL), Very speed Digital Subscriber Line (VDSL) and e.g.

International standards strong limit frequency bands premised for transmitting of downstream (in direction from Central office to home modem) and of upstream (in direction from home modem to Central Office) for different DSL system . As result , different DSL system may operate properly on the different twisted pairs of the same telephone cable.

Fig.1 illustrates Frequency band allocation plan for DSL system in accordance with ITU regulation. A "Plain Old Telephone Service" (POTS) occupies voice frequency band **101** up to 4 kHz. An Asymmetric Digital Subscriber Line (ADSL) uses digital multitone (DMT) line signals for communication between subscriber equipment and central office of telephone station . Central office ADSL Equipment transmits downstream data by modulation of about 200 tones in frequency band **103** from 200 kHz to 1100 kHz and receives about 30 tones of upstream data in frequency band **105** from 28 kHz to 140 kHz . ADSL is able to transmit downstream data with speed up to 10 Mb/s and upstream data with speed up to 1 Mb/s. ADSL was specially developed for long cable lines with length up to 4.5 km.

The VDSL may transmit information with much more bit rate : downstream data up to 56 Mb/s and upstream data up to 26 Mb/s but works only on short cable line up to 1.5 km.

As shown on Fig.1 for VDSL system define 4 frequency bands : two for downstream transmission (one band **107** from 0.3 MHz to 3 MHz and another band **109** from 7MHz to 10 MHz), and two bands for upstream transmission (one band **111** from 3.2 MHz to 5 MHz and another band **113** from 10 MHz to 15 MHz). Depends on cable length and necessary bit rate said bands are used partially or completely . VDSL may be realized as with DMT line signal so with CAP modulation.

The most wide-spread ADSL is point to point connected circuit and includes an ADSL modem on each end of the twisted pair telephone line, creating three information channels - a high speed downstream (central office to end user) channel, a medium speed upstream (end user to central office) channel, and a POTS ("Plain Old Telephone Service") channel. The POTS channel

is separated from the ADSL modem by filters, thus guaranteeing uninterrupted POTS, even if the ADSL circuit fails. While description is provided in terms of the POTS channel, telephone voice communications signals, telephone instruments, and the like for the benefit of familiarity, it should be understood that telephone equipment and signals need not be limited to voice communications, but may also include other technologies, for example equipment and signals compatible with regular telephone lines, such as facsimiles machines, voice band modems (for example, V.90 modems), answering machines, and the like.

Two variants of ADSL systems are available today - full-rate ADSL in accordance with the T1E1.413 or ITU G.992.1 standards and "splitterless" ADSL defined by the ITU G.992.2 standard. Full-rate ADSL uses POTS splitters to separate the POTS channel from the ADSL data signals. A POTS splitter is installed at each end of the line and includes a lowpass filter for separating out POTS telephone voice communication signals and a highpass filter for separating out data communication signals.

The POTS splitter divides the subscriber line into two separate twisted pairs - one for data communication (ADSL) and one for telephone voice communication signals (POTS). As a result, the existing two-wire internal house telephone wiring is not usable for ADSL. New wiring must be installed from the splitter to the modem, resulting in increased installation cost.

Splitterless ADSL can be installed without the need for additional home wiring. In this case, the ADSL modem includes a high-pass filter that rejects the POTS telephone voice communication signal, while every telephone instrument in the house is connected to the telephone line through a low-pass microfilter that rejects the ADSL line signals.

Splitterless ADSL has big business advantage because it is "Bay and Plug" system. A Customer no need any special service from telephone company to install ADSL home equipment. A customer may only bay an ADSL home modem and number of microfilters (according with number of telephones in the house) and simple plug those devises into existing telephone

connectors.

More, several PC vendors as Compaq and Intel include splitterless ADSL modem (G.LIGHT modem) into motherboard of new PC and supply with PC several microfilters.

FIG. 2 is a block diagram illustrating a splitterless ADSL system **201** of the prior art. Number of Subscriber premises **203** are coupled to central office (CO) **209** by telephone cable **217** comprising plurality twisted pair subscriber telephone lines **207** . At the subscriber premise **203** placed customer premises equipment that includes two personal computers (PC) **225** , printer **227** , fax **221** and telephone **223** . One PC **225** connected to another PC **225** and to printer **227** by parallel port cable **229.** A ADSL modem **205** connected directly to telephone line **207** and by Ethernet cable **224** to one of the PC **225**. A fax **221** and a telephone **223** are connected to telephone line **207** by microfilters **219**. CO **209** includes an ADSL Office Equipment **211**, data switch **235**, voice switch **237**, data network **215**, and voice network **213**. Each twisted pair subscriber telephone line **207** is coupled to POTS splitter **231**, which is coupled to voice switch **237** and ADSL office modem **233**. Voice switch **237** is coupled to voice network **213**. ADSL office modem **233** is coupled to data switch **235**, which is coupled to data network **215**.

Voice communications passing through voice switch **237** are passed through POTS splitter **231** and applied to twisted pair **207** as baseband signals. Data communications passing through data switch **235** are modulated at a frequency range higher than that of the baseband POTS signals and passed through POTS splitter **231** and applied to twisted pair **207**. Since the data communications are transmitted at a different frequency range than the voice communications, frequency-division-multiplexing (FDM) allows simultaneous transmission of both voice communications (POTS) and data communications over a single twisted pair 207.

A standard ADSL system has some disadvantages and problems.

One problem of existing ADSL system is that said system is always connected. It means that ADSL modem continuously transmits and receives DMT signals independently of transmits

useful information or no. As result of this fact plurality of ADSL modems of the Central office work continuously and consume much energy.

From another side only one ADSL home modem may be connected to the telephone line in the home because frequency bands of upstream and downstream are always busy.

In during of the last time this problem becomes actual because about 20 million subscribers in USA have more than one PC inside the home. In case that two o more PC in the home have internal ADSL modem , only one of them may be physically connected to telephone line. Every time that a customer want get Internet service from another PC he must connect this PC to telephone line and disconnect other PC's..

Another problem is that existing splitterless ADSL system is not supports communication between several computers in the home . It means that customer must have additional home data network like Ethernet and additional network equipment inside PC's.

Another problem is that existing ADSL home modems not may support future VDSL systems. A VDSL systems will be wide-spread in the word in during next 10-20 years. Telecom companies will replace existing ADSL Central Office Equipment with new VDSL Equipment, which will be able to support match more data bit rate . But most of customer will have difficulties with replacing existing PC's those have ADSL modem on the motherboard .

SUMMARY OF THE INVENTION

The present invention is directed to a method and apparatus for multipoint communication in a splitterless asymmetric digital subscriber line (ADSL) system. In accordance with present invention multipoint NDSL system includes a office ADSL modem placed at Central Office of Telephone Station and connected by twisted pair subscriber telephone line to number of NDSL modems at the subscribers premise . Each NDSL modem directly connected to the same home telephone line. Each NDSL modem may realize communication with any other home NDSL modem, placed at the same subscriber premise, or with office ADSL modem, placed at Central Office of Telephone Station. In accordance with present invention multipoint NDSL system provides not only data and voice service from Telephone Station but home network data communication too.

The communication technique provided by the invention for home network communication is different from technique provided by the invention for communication between NDSL modem and office ADSL modem.

In one embodiment of the invention a communication between NDSL modem and office ADSL modem realizes by activation standard ADSL communication FDM (Frequency - Devising- Multiplex) duplex protocol in during short communication cycles. . A communication cycle initializes by home PC which asks for NDSL modem to connect to Internet Provider. A NDSL modem connects to telephone line and activates standard ADSL communication protocol (in accordance with ITU G.992.2) and establishes communication with ADSL office modem. After a downloading of asked information , NDSL modem disables ADSL office modem and disconnects from telephone line .(The ITU G.992.2 standard premises several special commands for disabling office modem, which may be used by NDSL modem for realizing described Principe without any changing in existing CO ADSL Equipment).

In during an information exchange with CO downstream data transmits inside ADSL downstream frequency band **105**, upstream data transmits inside ADSL upstream frequency band **103**. All the time that information data is not transmitted between CO and any NDSL modems, ADSL upstream frequency band **103** may be used for home network communication.

A home data network communication may be established between any two NDSL modems, placed at the subscriber premise , using special communication technique.

In this case is used half-duplex mode of communication : one of the NDSL modems transmits data inside ADSL upstream frequency band **103** and another NDSL modem receives data inside ADSL upstream frequency band **103.** An information exchange between said NDSL modems is realized by transmitting data packets in two direction .

A control signals, necessary for establishing connection and properly work of packets translation protocol are transmitted by digital control tone that is not used in ADSL standard transmission and is not received by standard office ADSL modem.

Another embodiment of the invention uses for home data network communication several frequency bands: ADSL Upstream band **103** and number of VDSL Upstream bands **111, 113** and works with said half – duplex mode . In accordance with this embodiment of the invention a NDSL modem comprises universal ADSL / VDSL transmitter , which may transmit DMT line signals as in ADSL upstream frequency band 103 so in VDSL frequency bands **111, 113**. A NDSL modem comprises additional VDSL upstream receiver, that is used for Home Data Network communication.

In accordance with another embodiment of the invention a NDSL modem comprises universal ADSL / VDSL transmitter , which may transmit DMT line signals as in ADSL upstream frequency band 103 as in VDSL frequency bands 111, 113. A NDSL modem comprises additional VDSL upstream receiver, that is used for Home Data Network communication and additional VDSL downstream receiver . A universal ADSL / VDSL transmitter and additional VDSL

downstream receiver , those are may be used for communication with VDSL office modem , which will replace in the future an existing ADSL office Modem. Practically in this embodiment of invention a Customer Premises Equipment is "VDSL – READY."

Another embodiment of invention includes at the subscriber premise number of NDSL modems and number of simple N.Lite modems which may realize communication only inside home using ADSL upstream frequency band. N.Lite modems may be used for connection to Home Data Network so devices as printer, scanner and others, which no need coupling to CO.

Another embodiment of invention includes at the subscriber premise number of NDSL modems and number of simple N.Lite Set-top Boxes that may realize communication only inside home using ADSL upstream frequency band. An N.Lite Set-top Box includes in one embodiment an N.Lite modem and RF Transceiver, which supports radio communication with many different home devices and mechanism's like : air conditioner, lighting devices, electronic lock, and e.g.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates frequency bands allocation for xDSL system.

FIG. 2 is a block diagram illustrating a splitterless ADSL system of the prior art.

FIG. 3 is a block diagram illustrating one embodiment of the multipoint NDSL system. .

FIG. 4 is a block diagram illustrating one embodiment of the NDSL modem.

FIG. 5 is a flow chart of NDSL modem operation.

FIG. 6 is a block diagram illustrating one embodiment of the multipoint NDSL system.

FIG. 7 is a block diagram illustrating one embodiment of the NDSL modem

FIG. 8 is a block diagram illustrating one embodiment of the multipoint NDSL system.

FIG. 9 is a block diagram illustrating one embodiment of the NDSL modem

FIG. 10 is a block diagram illustrating one embodiment of the multipoint NDSL system.

FIG. 11 is a block diagram illustrating one embodiment of the NDSL modem

FIG. 12 is a block diagram illustrating one embodiment of the multipoint NDSL system.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a method and apparatus for multipoint communication in a asymmetric digital subscriber line (ADSL) system. . The communication technique of the invention provides for subscriber a multipoint data and voice service from Telephone Station and Home Network Data Service inside subscriber premise using number of NDSL modems. In accordance with the present invention, disadvantages and problems associated with "always connection" operation mode in ADSL have been substantially reduced.

One embodiment of a multipoint NDSL in accordance with the present invention includes at the subscriber premise number NDSL modems , each of them comprises ADSL Upstream Transmitter and ADSL Downstream Receiver for communication with ADSL office modem, and ADSL upstream receiver and TDM control tone receiver for home data network communication. An active NDSL modem transmits TDM control tone to inform other home modems that line is busy. The control tone carries information about which home modem is active and which home modem must receive data in the current communication cycle. Each home modem analyzes a control tone information and in case of matching received information with ID number of the modem enables its ADSL Upstream receiver. The control tone transmits on frequency that is not used for communication with CO and not activates an ADSL office modem. After finishing of data transmits , active NDSL modem disables its Upstream transmitter , stops control tone transmission and goes to stand-by state.

Another embodiment of multipoint NDSL system includes at the subscriber premise number NDSL modems , each of them further comprising an universal ADSL / VDSL upstream transmitter and VDSL upstream receiver for high speed home data network communication.

Another embodiment of multipoint NDSL system further comprises at the subscriber

premise number "VDSL -READY" NDSL modems , each of them comprises a VDSL downstream receiver for high speed data communication with future VDSL CO Equipment.

Another embodiment of multipoint NADSL system further comprises at the subscriber premise number of simple N.Lite modems ;

each simple N.Lite modem may transmits and receives line signals inside ADSL Upstream frequency band and supports only home data network communication .

Another embodiment of multipoint ADSL system further comprises at the subscriber premise number of N.Lite Set-top boxes , coupled to subscriber telephone line;

each N.Lite Set-top box comprises N.Lite modem and RF transceiver , and provides radio communication with number different home devices and mechanism's.

FIG. 3 illustrates one embodiment of a multipoint NDSL system **301.**. Number of Subscriber premises **203** are coupled to central office (CO) **209** by telephone cable **217** comprising plurality twisted pair subscriber telephone lines **207** . At the subscriber premise**203** is placed a customers equipment that includes two personal computers (PC) **225**, printer **227** , fax **221** and telephone **223** . One PC **225** connected to printer **227** by parallel port cable **229.** A first NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to first PC **225**. A second NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to second PC **225.** A fax **221** and a telephone **223** are connected to telephone line **207** by microfilters **219**. CO **209** includes an ADSL Office Equipment **211**, data switch **235**, voice switch **237** ,data network **215** , and voice network **213**. Each twisted pair subscriber telephone line **207** is coupled to POTS splitter **231** that is coupled to voice switch **237** and ADSL office modem **233**. A Voice switch **237** is coupled to voice network **213**. ADSL office modem **233** is coupled to data switch **235**, which is coupled to data network **215**.

Each NDSL modem **305** may be communicated as with ADSL office modem **233** so with another NDSL modem **305**.

In the case of communication with CO **209** NDSL modem **305** transmits upstream data with bit rate up to 1.0 Mb/s and receives downstream data with bit rate up to 10 Mb/s.

A NDSL modem **305** uses in this case line signals and communication protocols in accordance with existing ADSL standards (T1E1.413 or ITU G.992.1).

In during an information exchange with CO a downstream data transmits inside ADSL downstream frequency band **105**, an upstream data transmits inside ADSL upstream frequency band **103**. All the time that an information data is not transmitted between CO and any NDSL modems, ADSL upstream frequency band **103** may be used for home network communication.

For home data network communication between PC's **225** is used half-duplex protocol and an information transmits in two direction by data packets , with Time Division Multiplexing (TDM). In this case is used only ADSL Upstream Frequency band **103** and data exchange between PC's has bit rate up to 1.5 Mb/s.

A NDSL modem **305** uses in this case the same DMT line signals and different synchronization signals as existing ADSL standard.

A NDSL modem **305** comprises ADSL Upstream Transmitter and ADSL Downstream Receiver for communication with ADSL office modem, and ADSL upstream receiver and a control tone receiver for home data network communication. A NDSL modem that activates communication cycle, transmits a control tone to inform others home modems that line is busy. The control tone carries an information about ID number of home modem that is active and ID number of home modem that must receive data in the current communication cycle. Each home modem analyzes a control tone information and in case of matching received information with its own ID number, enables its ADSL Upstream receiver. The control tone transmits on frequency that is not used for communication with CO and not activate an ADSL office modem. After finishing of data transmits, active NDSL modem disables its an upstream Transmitter, stops a control tone transmission and goes to stand-by state.

Fig. 4 illustrates block diagram of the NDSL modem in accordance with said embodiment of the present invention.

A NDSL modem **305** comprises ADSL upstream receiver **403** , ADSL downstream receiver **405** , ADSL upstream transmitter **407**, data interface circuit **409**, communication Processor **411**, control tone receiver **413**, high impedance amplifier **415**, line transformer **417**, and control tone transformer **419**. A primary winding of the line transformer **417** is coupled to subscriber telephone line **207** by high pass filter capacitors **423**, and to primary winding of control tone transformer **419**. A secondary winding of the line transformer **417** is coupled to input of an ADSL upstream receiver **403** , to input of an ADSL downstream receiver **405** and to output of an ADSL upstream transmitter **407**. A secondary winding of a control tone transformer **419** is coupled to input of high impedance amplifier **415**, which output is connected to the input of a control tone receiver **413**. An input of ADSL Upstream transmitter **407**, an output of ADSL upstream receiver **403** and an output of ADSL downstream receiver **405** are connected to Data Interface Circuit **409** by digital buses **425**, **427**, **429**. A Data Interface Circuit **409** is coupled to a customers equipment by an Ethernet cable **224**. A Communication Processor **411** is coupled to ADSL upstream receiver **403**, to ADSL downstream receiver **405**, to ADSL upstream transmitter **407** , to control tone receiver **413** and to switch **433**, connected in parallel with primary winding of a control tone transformer **419**.

Fig.5 is a flow chart of NDSL modem operation .

At start of operation (501) NDSL modem goes to stand-by state (503). In this state a switch **433** is open and NDSL modem **305** has high input impedance produced by high impedance amplifier **415** and low frequency control tone transformer **419**. It makes possible connection several NDSL modems to the same subscriber telephone line **207.** An ADSL upstream transmitter **407**, ADSL upstream receiver **403** and ADSL downstream receiver 405 are disabled.

A control tone receiver **413** is enabled and a communication processor **411** is start to analyze an output signal of a control tone receiver **413** and a signals coming from Digital Interface Circuit **409**.

From stand-by state (**505**) NDSL modem goes to state **505**. In this state is analyzed output signal of control tone receiver (**413**). If a control tone is received, NDSL modem goes to state **507**, if no – to state **509**. In state **507** a communication processor analyzes an information carried by control tone and goes to state **511** to analyze a received data . If communication processor fixes matching of received data with its own ID (address), a NDSL modem goes to state **513** to begin communication with another home NDSL modem , if no – goes back to stand-by state **503**. In beginning of a communication (state **513**) is enabled ADSL upstream receiver , after that is enabled half-duplex protocol **515** and is enabled ADSL upstream transmitter **517**. Next state (**519**) is a communication cycle between two NDSL modems. In during this state (**519**) NDSL modem receives and transmits packets of data in accordance with half-duplex protocol. After transmission or receiving every data packet a NDSL modem asks for PC :" is a communication cycle ended or no? " (state **521**). If no – NDSL modem is continue to transmit (to receive) next data packets (**511**). If communication cycle is ended, a NDSL modem disables an upstream receiver, an upstream transmitter and stops of a control tone transmission , to inform another devices , that telephone line is free **523**. After this a NDSL modem is disconnected from line **525** and goes to a stand-by state **503**.

If in a state **505** a control tone is not received, NDSL modem goes to the state **509**. If PC is asking for communication , a NDSL modem goes to state **531**, if no – goes back to a stand-by state **503**.

In the state **531** , NDSL modem is connected to telephone line, enables upstream transmitter and starts control tone transmitting to inform any other devices that line is busy. In Next state **535** must be defined, what kind of communication needs PC. In the case of communication with

another NDSL modem **537** , is transmitted information about ID number of modem ,which must be connected to active modem in current communication cycle (state **539**) , after that NDSL modem goes to state **513** to enable upstream receiver. In the case of communication with CO (**541**) is enabled ADSL Downstream receiver (**543**). In during communication with CO (state **545**) is used standard ADSL duplex protocol and modem operate in FDM mode . Periodically, modem asks for PC: "if a communication cycle is ended ?" (state **547**). If communication cycle is ended , a modem goes to state **523**, if no- is continue to communication cycle **547**.

FIG. 6 illustrates one embodiment of a multipoint NDSL system **601.** A number of subscriber premises **203** coupled to central office (CO) **209** by telephone cable **217** comprising plurality twisted pair subscriber telephone lines **207** . At the subscriber premise **203** placed a customers equipment that includes two personal computers (PC) **225**, printer **227** , fax **221** and telephone **223** One PC **225** connected to printer **227** by parallel port cable **229.** A first NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to first PC **225**. A second NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to second PC **225.** A fax **221** and a telephone **223** are connected to telephone line **207** by microfilters **219**. An additional video Equipment placed at the subscriber premise**203** comprises **HDTV** television **655,** a tape video recorder **653** and DVD player **651**. Each video device is coupled to high speed NDSL modem **605** by digital cable **324.** Each high speed NDSL modem **605** is directly connected to telephone line **207**. CO **209** includes an ADSL Office Equipment **211**, data network **215**, and voice network **213**. Each twisted pair subscriber telephone line **207** is coupled to POTS splitter **231**, that is coupled to voice network **213** and ADSL office modem **233**. ADSL office modem **233** is coupled to data network **215**.

Each high speed NDSL modem **605** is able to support communication as with ADSL office modem **233** so with another a high speed NDSL modem **605** or with another NDSL modem **305.**

In the case of communication with CO, a high speed NDSL modem has the same characteristic as a conventional ADSL modem : transmits upstream data with bit rate up to 1.0 Mb/s and receives downstream data with bit rate up to 10 Mb/s.

A high speed NDSL modem **605** uses in this case line signals and communication protocols in accordance with existing ADSL standards (T1E1.413 or ITU G.992.1) . In during an information exchange with CO a downstream data is transmitting inside ADSL downstream frequency band **105**, an upstream data is transmitting inside ADSL upstream frequency band **103**.

For home data network communication is used half-duplex protocol and an information transmits in two direction by data packets with Time Division Multiplexing (TDM). In this case a NDSL modem **305** uses only ADSL Upstream Frequency band **103** and a data exchange between NDSL modems **305** realizes with bit rate up to 1.5 Mb/s. A high speed NDSL modem 605 uses for data network communication an ADSL Upstream Frequency band **103** and number VDSL Upstream frequency bands **111,113**. A data exchange between high speed NDSL modems may have bit rate up to 12 Mb/s (in the case of using only first VDSL upstream band **111**) or up to 50 Mb/s (in the case of using first **111** and second VDSL upstream bands **113**).
A high speed NDSL modem **605** transmits in this case the DMT line signals inside ADSL and VDSL upstream bands .

A high speed NDSL modem **605** comprises universal ADSL / VDSL Upstream Transmitter and ADSL Downstream Receiver for communication with ADSL office modem, and ADSL upstream receiver , VDSL Upstream receiver and control tone receiver for home data network communication. An universal ADSL / VDSL transmitter is able to transmit DMT signals only in ADSL Upstream frequency band 103 for communication with ADSL office modem and additional DMT tones in VDSL Upstream frequency bands 111, 113 for communication with another high-speed NDSL modem. A high speed NDSL modem that activates communication cycle transmits a control tone to inform other home modems that line is busy. The control tone

carries information about which home modem is active and which home modem must receive data in the current communication cycle. Each high speed home modem analyzes a control tone information and in case of matching received information with its own ID number enables its ADSL and VDSL Upstream receives. The control tone transmits on frequency that is not used for communication with CO and not activates an ADSL office modem. After finishing of data transmits , active high speed NDSL modem disables its Upstream transmitter , stops control tone transmission and goes to stand-by state.

Fig. 7 illustrates block diagram of the high speed NDSL modem **605** in accordance with said embodiment of the present invention.

A high speed NDSL modem **605** comprises ADSL Upstream receiver **403** , ADSL Downstream receiver **405** , VDSL Upstream receiver **453** , an universal ADSL / VDSL Upstream transmitter **477**, Data Interface Circuit **409**, Communication Processor **411**, control tone receiver **413**, high impedance amplifier **415**, line transformer **417**, and Control tone transformer **419**. A primary winding of the line transformer **417** is coupled to subscriber telephone line **207** by high pass filter capacitors **423**, and to primary winding of control tone transformer **419**. A secondary winding of the line transformer **417** is coupled to input of an ADSL upstream receiver **403** , to input of an ADSL downstream receiver **405** and to output of an ADSL / VDSL upstream transmitter **477**. A secondary winding of a control tone transformer **419** is coupled to input of high impedance amplifier **415**, which output is connected to the input of a control tone receiver **413**. An input of ADSL / VDSL Upstream transmitter **477** , an output of ADSL upstream receiver **403** , an output of VDSL upstream receiver **453** and an output of ADSL downstream receiver **405** are connected to Data Interface Circuit **409** by digital buses **425**, **427**, **429**. A Data Interface Circuit **409** is coupled with customer premises equipment by cable **324**. A Communication Processor **411** is coupled to ADSL upstream receiver **403**, to VDSL upstream receiver **453** , to ADSL downstream receiver **405**, to ADSL / VDSL upstream transmitter **477** , to control tone receiver **413** and to

switch **433** , connected in parallel with primary winding of control tone transformer **419**.

FIG. 8 illustrates one embodiment of a multipoint NDSL system **801.** Number of Subscriber premises **203** are coupled to central office (CO) **209** by telephone cable **217** comprising plurality twisted pair subscriber telephone lines **207** . At the subscriber premise **203** placed customers equipment that includes two personal computers (PC) **225** , printer **227** , fax **221** and telephone **223** One PC **225** connected to printer **227** by parallel port cable **229.** A "VDSL-READY" NDSL modem **805** connected directly to telephone line **207** and by Ethernet cable **224** to first PC **225**. A "VDSL-READY" NDSL modem **805** connected directly to telephone line **207** and by Ethernet cable **224** to second PC **225.** A fax **221** and a telephone **223** are connected to telephone line **207** by microfilters **219**. A video Equipment placed at the subscriber premise **203** comprises **HDTV** television **855,** tape video recorder **853** and DVD player **851**. Each video device is coupled to "VDSL-READY" NDSL modem **805** by digital cable **324.** Each "VDSL-READY" NDSL modem **805** is directly connected to telephone line **207**. CO **209** includes an ADSL Office Equipment **211**, data network **215**, and voice network **213**. Each twisted pair subscriber telephone line **207** is coupled to POTS splitter **231**, which is coupled to voice network **213** and ADSL office modem **233**. ADSL office modem **233** is coupled to data network **215**. CO additionally future comprising a VDSL office equipment **861** that will replace ADSL office equipment **211**. A VDSL office equipment **861** includes number of VDSL office modems **865**. Each "VDSL-READY" NDSL modem **805** may be communicated as with ADSL office modem **233** so with VDSL office modem **865**, which will replace ADSL office modem 233. Each "VDSL-READY" NDSL modem **805** may be communicated with another "VDSL-READY" NDSL modems **805** or with high speed NDSL modem **605** or with NDSL modem **305,** placed at the same subscriber premise.

In the case of communication with CO **209 ADSL** office equipment 211 , "VDSL-READY" NDSL modem **805** transmits upstream data with bit rate up to 1.0 Mb/s and receives

downstream data with bit rate up to 10 Mb/s.

A "VDSL-READY" NDSL modem **805** uses in this case line signals and communication protocols in accordance with existing ADSL standards (T1E1.413 or ITU G.992.1).

In during an information exchange with CO ADSL equipment 211 a downstream data transmits inside ADSL downstream frequency band **105**, an upstream data transmits inside ADSL upstream frequency band **103**..

In the case of communication with CO **209 VDSL** office equipment 811 , "VDSL-READY" NDSL modem **805** transmits upstream data with bit rate up to 28.0 Mb/s and receives downstream data with bit rate up to 50 Mb/s.

A "VDSL-READY" NDSL modem **805** uses in this case line signals and communication protocols in accordance with existing VDSL standards .

In during an information exchange with CO VDSL equipment 211 a downstream data transmits inside VDSL downstream frequency bands **107, 109,** upstream data transmits inside VDSL upstream frequency bands **111, 113**.

For home data network communication is used half-duplex protocol and an information transmits in two direction by data packets , with Time Division Multiplexing (TDM). In this case a "VDSL-READY" NDSL modem **805** uses for data network communication as an ADSL upstream frequency band **103** and so a number of VDSL upstream frequency bands **111,113**. A data exchange between "VDSL-READY" NDSL modems may have bit rate up to 12 Mb/s (in the case of using only first VDSL upstream band **111**) or up to 28 Mb/s (in the case of using first **111** and second VDSL upstream bands **113**).

A "VDSL-READY" NDSL modem **805** uses in this case the DMT line signals that are transmitted in ADSL and VDSL upstream bands .

A "VDSL-READY" NDSL modem **805** comprises universal ADSL / VDSL Upstream Transmitter and an ADSL downstream Receiver for communication with ADSL office modem,

VDSL downstream Receiver for communication with VDSL office modem, and ADSL upstream Receiver, VDSL upstream Receiver and a control tone Receiver for home data network communication. An universal ADSL / VDSL transmitter is able to transmit DMT signals only in ADSL Upstream frequency band 103 for communication with ADSL office modem, only in VDSL Upstream bands 111,113 for communication with VDSL office modem , and in both ADSL and VDSL Upstream frequency bands 103, 111, 113 for communication with another "VDSL-READY" NDSL modem. A "VDSL-READY" NDSL modem 805, that activates communication cycle, transmits a control tone to inform other home modems that line is busy. The control tone carries information about which home modem is active and which home modem must receive data in the current communication cycle. Each home modem analyzes an control tone information and , in case of matching received information with its own ID number, enables its ADSL and VDSL Upstream receivers . The control tone transmits on frequency that is not used for communication with CO and not activates an ADSL office modem. After finishing of data transmits , active "VDSL-READY" NDSL modem disables its Upstream transmitter , stops control tone transmission and goes to stand-by state.

Fig. 9 illustrates block diagram of the "VDSL-READY" NDSL modem **805** in accordance with said embodiment of the present invention. A "VDSL-READY" NDSL modem **805** comprises ADSL dpstream receiver **403** , ADSL downstream receiver **405** , VDSL upstream receiver **453** , an universal ADSL / VDSL upstream transmitter **477**, a data interface circuit **409**, a communication Processor **411**, a control tone receiver **413**, high impedance amplifier **415**, a line transformer **417**, and control tone transformer **419**. A primary winding of the line transformer **417** is coupled to subscriber telephone line **207** by high pass filter capacitors **423**, and to primary winding of control tone transformer **419**. A secondary winding of the line transformer **417** is coupled to input of an ADSL upstream receiver **403** , to input of an ADSL downstream receiver **405** and to output of an ADSL / VDSL upstream transmitter **477**. A secondary winding of a

control tone transformer **419** is coupled to input of high impedance amplifier **415**, which output is connected to the input of a control tone receiver **413**. An input of ADSL / VDSL Upstream transmitter **477** , an output of ADSL upstream receiver **403** , an output of VDSL upstream receiver **453** and an output of ADSL downstream receiver **405** are connected to data interface circuit **409** by digital buses **425, 427, 429**. A data interface circuit **409** is coupled with customers equipment by cable **324**. A Communication Processor **411** is coupled to ADSL upstream receiver **403**, to VDSL upstream receiver **453** , to ADSL downstream receiver **405**, to ADSL / VDSL upstream transmitter **477** , to control tone receiver **413** and to switch **433** , connected in parallel with primary winding of control tone transformer **419**. A "VDSL-READY" NDSL **805** modem comprises additionally VDSL Downstream receiver **865** to realize a communication between "VDSL-READY" NDSL modem **805** and VDSL CO equipment **811** , which will be replace existing ADSL CO equipment **211** in the future.

FIG. 10 illustrates one embodiment of a multipoint NDSL system **1001.** Number of Subscriber premises **203** are coupled to central office (CO) **209** by telephone cable **217** comprising plurality twisted pair subscriber telephone lines **207** . At the subscriber premise**203** placed customers equipment that includes two personal computers (PC) **225** , printer **227** , fax **221** and telephone **223.** A NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to first PC **225**. A NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to second PC **225.** A fax **221** and a telephone **223** are connected to telephone line **207** by microfilters **219**. A printer **225** and scanner **1007** are connected by Ethernet cable **224** to simple N.Lite modems **1005**. Each N.Lite modem **1005** is connected directly to telephone line **207**. CO **209** includes an ADSL Office Equipment **211**, ,data network **215** , and voice network **213**. Each twisted pair subscriber telephone line **207** is coupled to POTS splitter **231**, which is coupled to voice network **213** and ADSL office modem **233**. ADSL office modem **233** is coupled to data network **215**. Each N.Lite modem **1005** may be communicated

only with another N.Lite modem **1005** or with a NDSL modems **305**, placed at the same subscriber premise. An N.Lite modem **1005** may support only home data network communication.

For home data network communication is used half-duplex protocol and an information transmits in two direction by data packets with Time Division Multiplexing (TDM). In this case an N.Lite modem **1005** uses for data network communication only ADSL upstream frequency band **103** . A data exchange between N.Lite modems **1005** may have bit rate up to 1.5 Mb/s .

A N.Lite modem **1005** uses in this case transmits and receives DMT line signals only in ADSL upstream band **103** .

Fig.11 illustrates block diagram of the N.Lite modem **1005** in accordance with said embodiment of the present invention.

An N.Lite modem **1005** comprises ADSL upstream Transmitter , ADSL upstream receiver and control tone receiver for home data network communication. An ADSL transmitter is able to transmit DMT signals only in ADSL Upstream frequency band **103,** for communication with another NDSL modem, and a control tone . The control tone carries information about ID number of an active modem and which home modem must receive data in the current communication cycle. Each home modem analyzes a control tone information and in case of matching received information with its own ID number, the modem enables its ADSL upstream receiver . The control tone transmits on frequency that is not used for communication with CO and not activates an ADSL office modem. After finishing of data transmits , active NDSL modem disables its Upstream transmitter , stops control tone transmission and goes to stand-by state.

FIG. 12 illustrates one embodiment of a multipoint NDSL system **1201.**. Number of Subscriber premises **203** are coupled to central office (CO) **209** by telephone cable **217** comprising plurality twisted pair subscriber telephone lines **207** . At the subscriber premise**203** placed customer premises equipment that includes two personal computers (PC) **225** , printer **227** , fax **221** and

telephone **223**. A NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to first PC **225**. A NDSL modem **305** connected directly to telephone line **207** and by Ethernet cable **224** to second PC **225**. A fax **221** and a telephone **223** are connected to telephone line **207** by microfilters **219**. A printer **225** is connected by Ethernet cable **224** to simple N.Lite modem **1005**. An N.Lite modem **1005** is connected directly to telephone line **207**. A NDSL Set-top box **1205** is connected directly to the telephone line **207**.

A NDSL set-top block includes N.Lite modem **1005** and RF transceiver **1207** and controls by radio frequency number of mechanical and electrical devices in the home.

Although the present invention has been described with several embodiments , a myriad of changes, variations, alterations, ,and modifications may be suggested to one skilled in the art, and it is intended that the present invention encompass such changes, variations, alterations , and modifications as fall within the spirit and scope of appended claims .

CLAIMS

The claimed invention is as follows:

1. A multipoint digital subscriber line communication system with home network ability (NDSL), comprising :

A xDSL office modem placed at CO of telephone station and coupled by twisted pair of telephone cable to subscriber premise; a xDSL office modem includes downstream transmitter and upstream receiver those are using for communication with subscriber premise in during short communication cycles; and

A number of telephones placed at subscriber premise and coupled to said twisted pair, and

A number of NDSL (Network DSL) modems placed at subscriber premise and directly connected to said twisted pair; each NDSL modem comprises upstream transmitter and downstream receiver those are using for communication with CO in during said communication cycles , and upstream receiver that is using for communication with others NDSL modems, placed at the same subscriber premise, in during time intervals those are not used for said communication cycles.

2. A communication system of claim 1 , comprising :

An ADSL office modem placed at CO of telephone station and coupled by twisted pair of telephone cable to subscriber premise; a ADSL office modem that transmits data in ADSL downstream frequency band and receives data in ADSL upstream frequency band ; and

A number of telephones placed at subscriber premise and coupled to said twisted pair, and

A number of NDSL modems placed at subscriber premise and directly connected to said twisted pair; each NDSL modem transmits data in ADSL upstream frequency band and receives data in ADSL downstream frequency band in during said communication cycles ; each NDSL modem transmits data in ADSL upstream frequency band and receive data in ADSL upstream frequency band in during different time intervals those are not used for said communication cycles.

3. A communication system of claim 2 , further comprising :

A number of High Speed NDSL modems placed at subscriber premise and directly connected to said twisted pair; each High Speed NDSL modem comprises universal ADSL/VDSL upstream transmitter and VDSL upstream receiver ; each High Speed NDSL modem transmits data in ADSL upstream frequency band and receive data in ADSL downstream frequency band in during said communication cycles ; each High Speed NDSL modem transmits data in ADSL upstream frequency band and (or) in number of VDSL upstream frequency bands, and receives data in ADSL upstream frequency band and (or) in number of VDSL upstream frequency bands in during different time intervals those are not used for said communication cycles.

4. A communication system of claim 3 , further comprising :

A number of "VDSL-READY" NDSL modems placed at subscriber premise and directly connected to said twisted pair; each "VDSL-READY" NDSL modem comprises universal ADSL/VDSL upstream transmitter, VDSL upstream receiver and additional VDSL downstream receiver ; each "VDSL-READY" NDSL modem transmits data in ADSL upstream frequency band and receives data in ADSL downstream frequency band in during said communication cycles with ADSL CO Equipment ; each "VDSL-READY" NDSL modem transmits data in number of VDSL upstream frequency band and receives data in number of VDSL downstream frequency bands in during said communication cycles with VDSL CO Equipment; each "VDSL-READY" NDSL modem transmits data in ADSL upstream frequency band and receive data in ADSL upstream frequency band in during communication with NDSL modem of claim 2 ; each "VDSL-READY" High Speed NDSL modem transmits data in ADSL upstream frequency band and (or) in number of VDSL upstream frequency bands, and receives data in ADSL upstream frequency band and (or) in number of VDSL upstream frequency bands in during communication with another High Speed NDSL modem of claim 3 , or with another " VDSL-READY" NDSL modem.

5. A communication system of claim 2 , further comprising :

A number of N.Lite (simplest NDSL modem) modems placed at subscriber premise and directly

connected to said twisted pair; each N.Lite modem comprises ADSL upstream transmitter and ADSL upstream receiver ; each modem transmits data only in ADSL upstream frequency band and receives data only in ADSL upstream frequency band and may support communication only with another NDSL modem placed at the same subscriber premise.

6. A communication system of claim 5 , further comprising :

A number of NDSL Set-Top Boxes placed at subscriber premise and directly connected to said twisted pair; each NDSL Set-Top Box ADSL comprises a N.Lite modem connected to RF Transceiver that provides wireless control of different mechanisms and electric devices placed inside customers apartment.

7. An NDSL modem of claim 1 further comprising:

a device for transmitting of a control tone that carries an information necessary for establishing of a communication with another NDSL modem,

a device for receiving of said control tone.

8. An NDSL modem of claim 7 further comprising ;

a control tone transformer coupled to said twisted pair ,

a switch connected in parallel with primary winding of said control tone transformer.

9. A method of multipoint data communication for use with xDSL equipment, said method comprising :

using downstream frequency interval and upstream frequency interval of xDSL equipment for duplex communication between office xDSL modem and number of home xDSL modems, and

using upstream frequency interval of xDSL equipment and time - division multiplexing for half-duplex communication between number of home xDSL modems, placed inside subscriber premise.

10. The method of claim 9, further comprising

using different time intervals for duplex communication between office xDSL modem and home xDSL modem and for half-duplex communication between number of home xDSL modems inside subscriber premise (home network communication).

11. A method of claim 9, further comprising

using Frequency Divide Multiplexing method for duplex communication between office xDSL modem and home xDSL modem, and

using Time Divide Multiplexing method for transmission an information between number of home xDSL modems inside subscriber premise.

12. The method of claim 9, further comprises

transmitting by active xDSL home modem a special control tone, which indicates home network operation mode and carries an information necessary for establishing a communication with another xDSL home modem .

13. A method of claim 9, further comprising

transmitting an information between home xDSL by data packets ,

controlling of data packets exchange by synchronization signal carried by said control tone.

14. The method of claim 9, further comprises :

using in the case of communication between office xDSL modem and number of home xDSL modems a standard xDSL upstream signal structure , and

using in the case of home network communication different upstream signal structure that is not perceives by office xDSL modem.

INVENTOR:
ROMAN VITENBERG

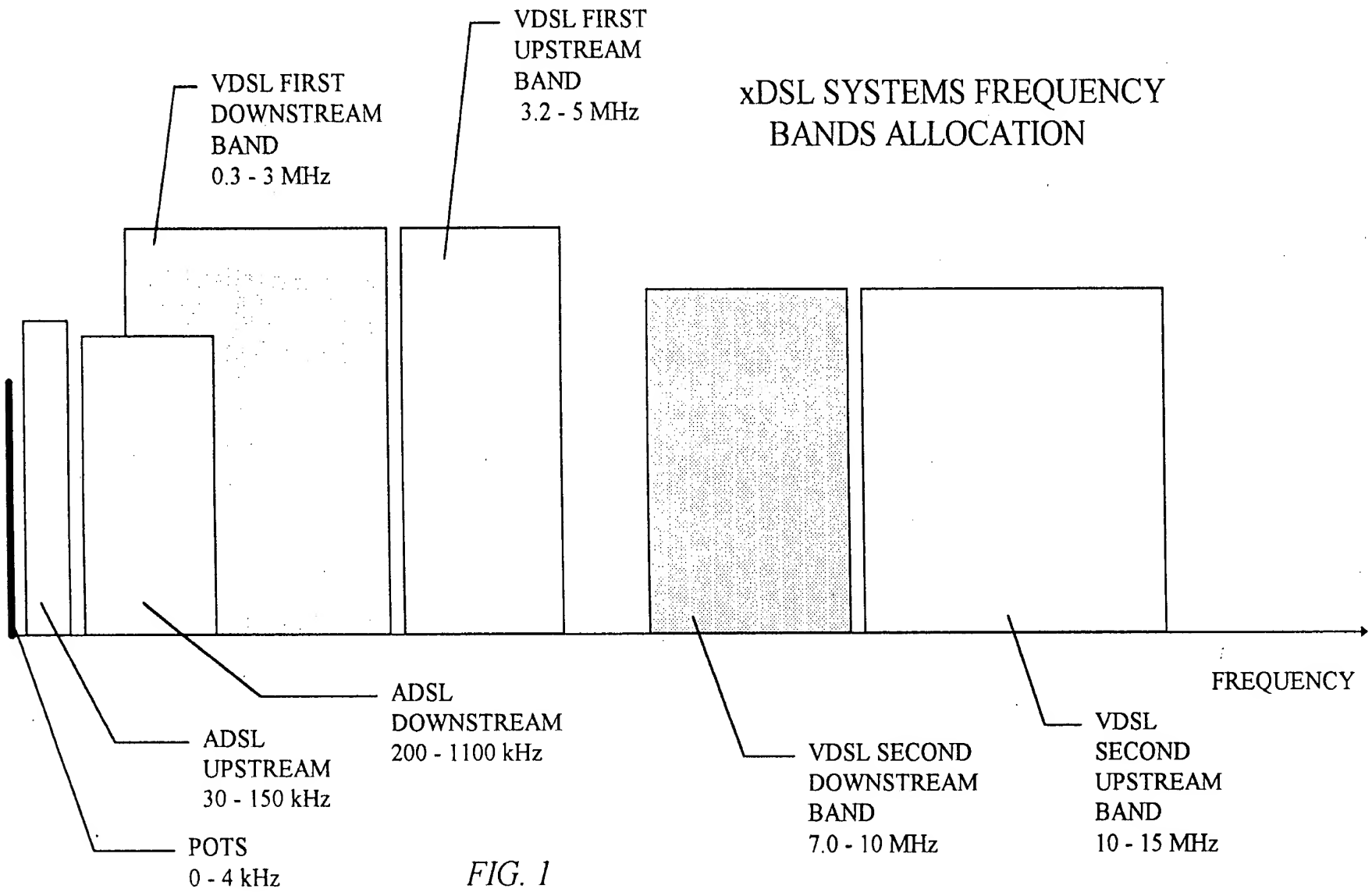
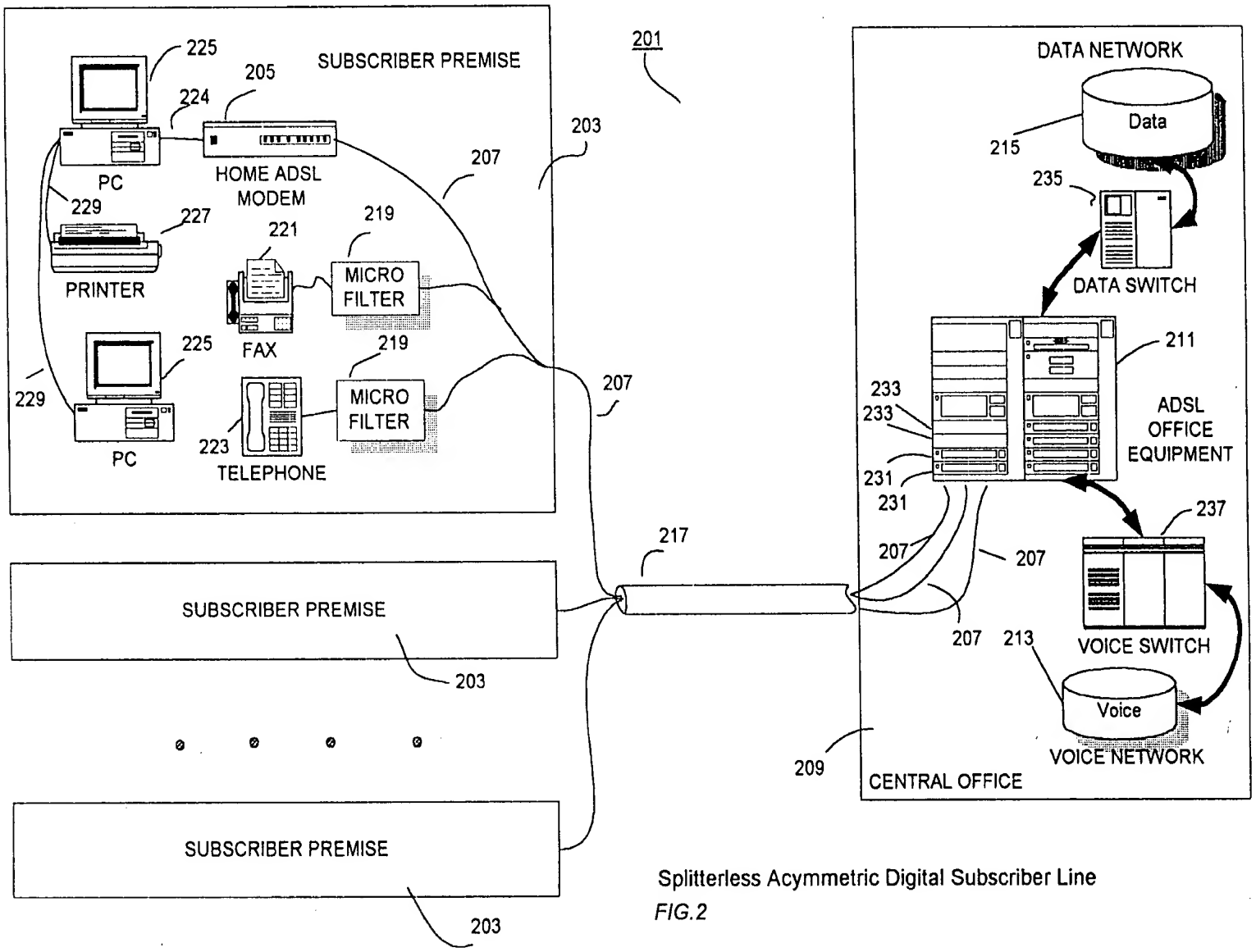
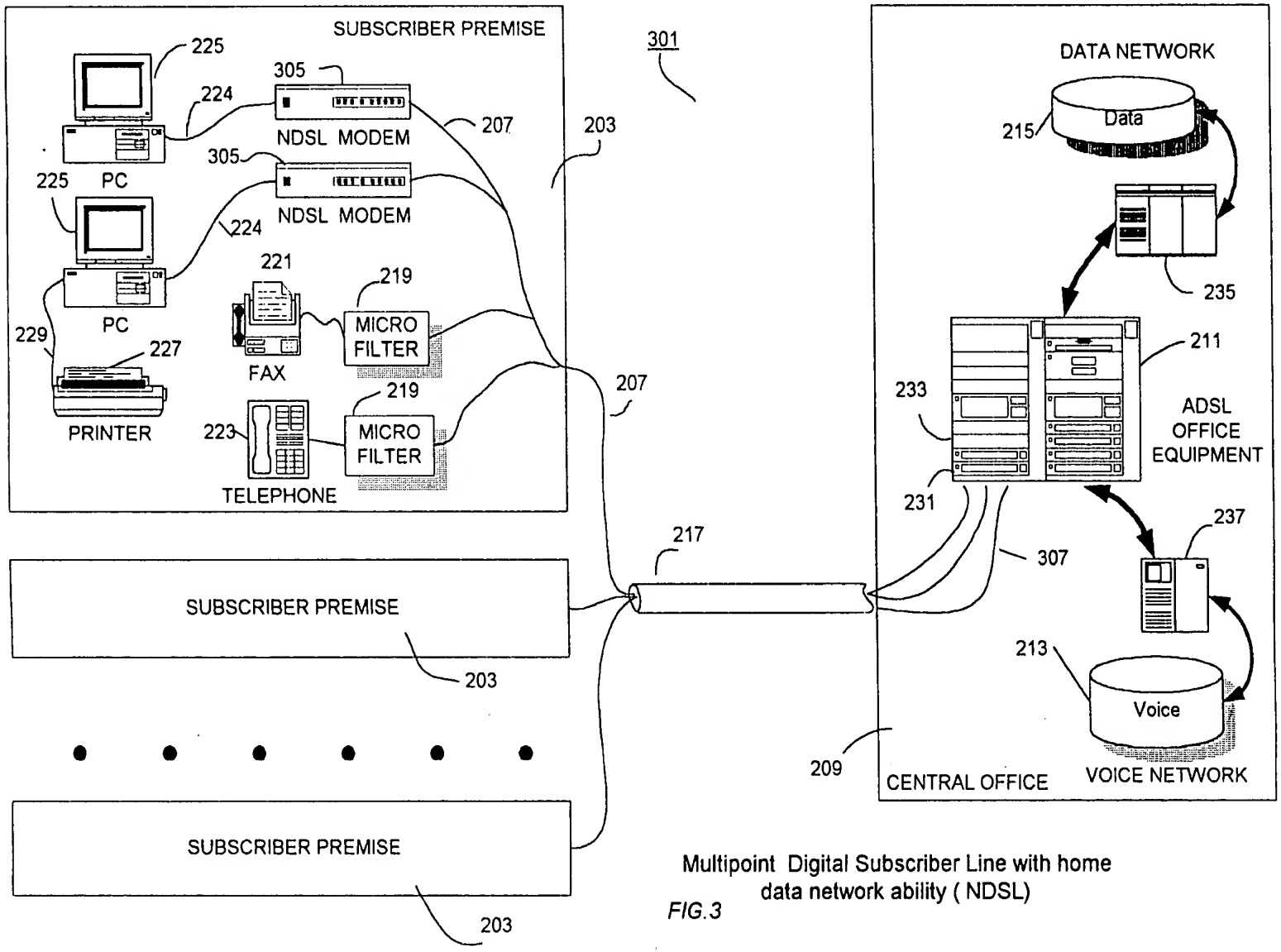

xDSL SYSTEMS FREQUENCY BANDS ALLOCATION
VDSL FIRST DOWNSTREAM BAND 0.3 - 3 MHz
VDSL FIRST UPSTREAM BAND 3.2 - 5 MHz
ADSL DOWNSTREAM 200 - 1100 kHz
ADSL UPSTREAM 30 - 150 kHz
POTS 0 - 4 kHz
VDSL SECOND DOWNSTREAM BAND 7.0 - 10 MHz
VDSL SECOND UPSTREAM BAND 10 - 15 MHz
FREQUENCY

FIG. 1



Splitterless Acymmetric Digital Subscriber Line

FIG.2



Multipoint Digital Subscriber Line with home data network ability (NDSL)

FIG.3

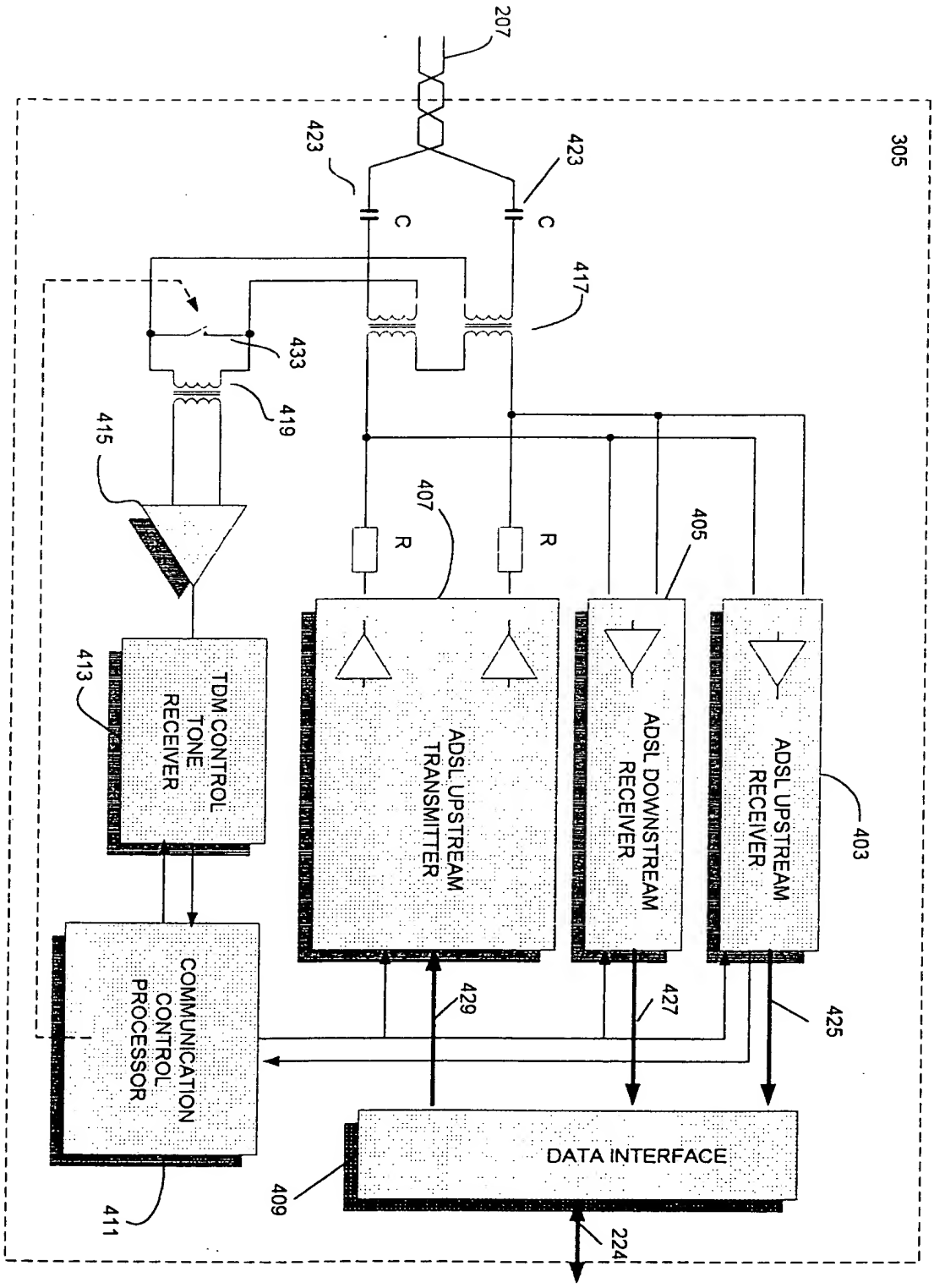

305
207
423
423
C
C
417
433
419
415
407
R
R
405
ADSL UPSTREAM TRANSMITTER
ADSL DOWNSTREAM RECEIVER
ADSL UPSTREAM RECEIVER
403
TDM CONTROL TONE RECEIVER
413
COMMUNICATION CONTROL PROCESSOR
411
429
427
425
DATA INTERFACE
409
224

FIG.4

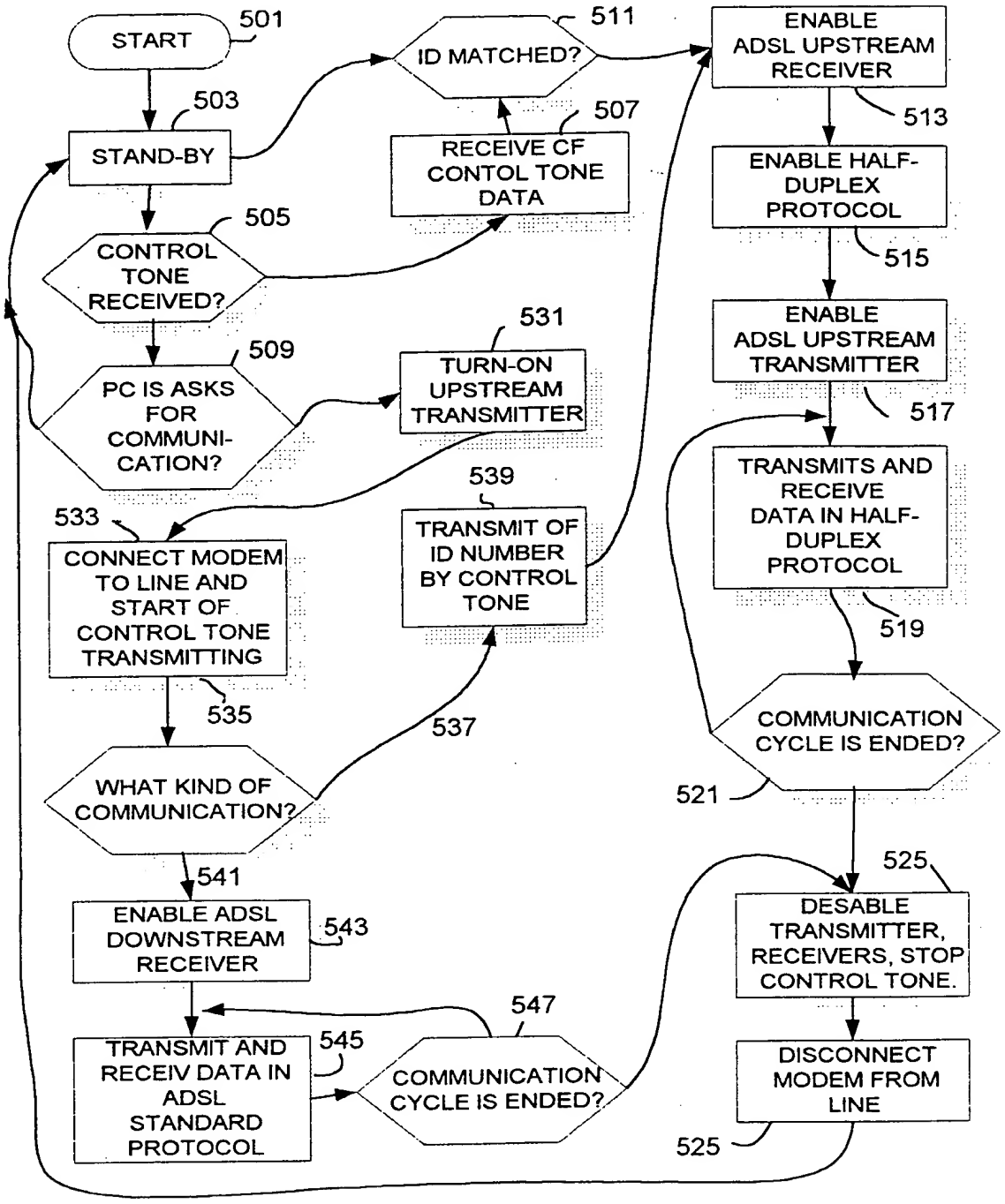
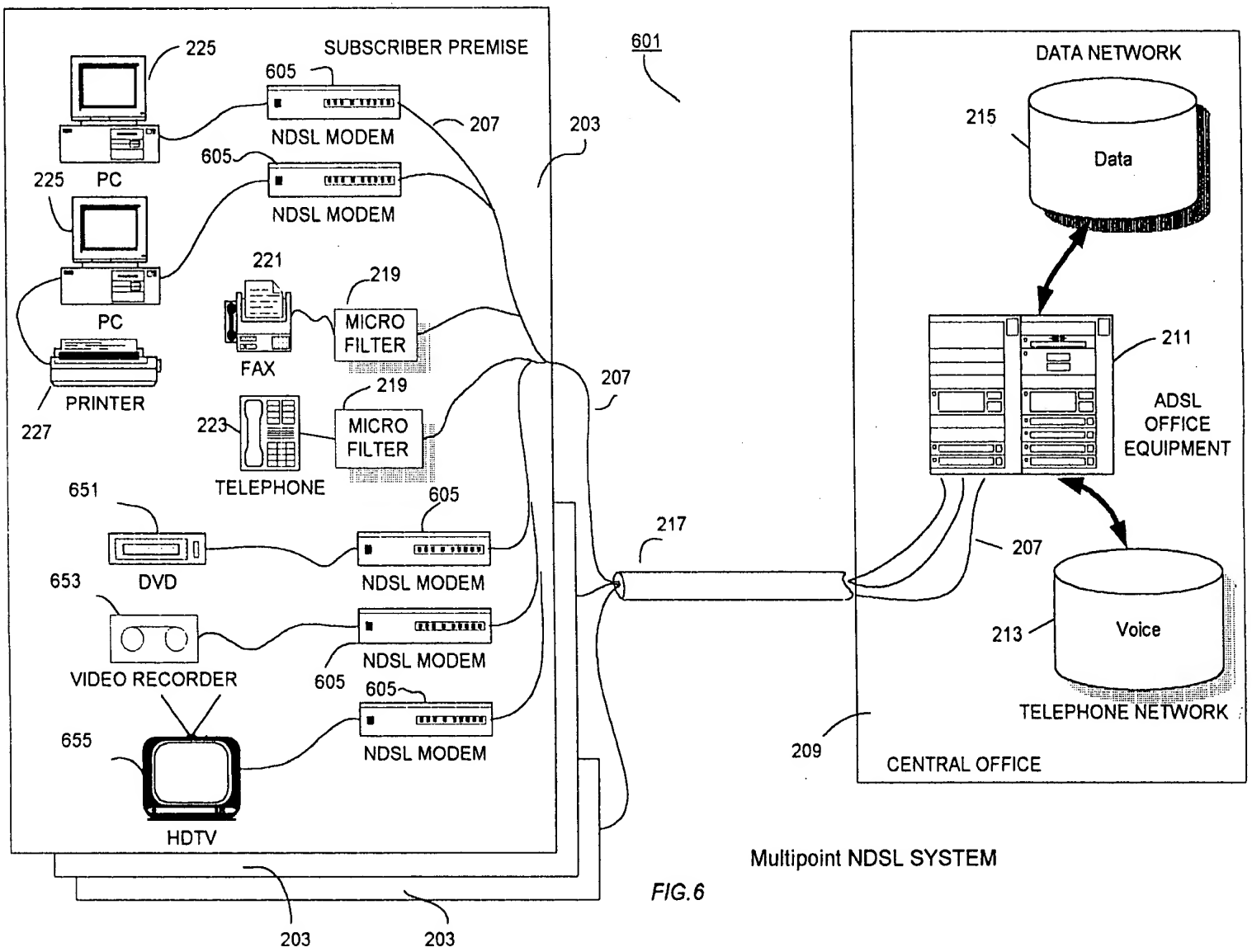

START
501
STAND-BY
503
CONTROL TONE RECEIVED?
505
PC IS ASKS FOR COMMUNI-CATION?
509
CONNECT MODEM TO LINE AND START OF CONTROL TONE TRANSMITTING
533
WHAT KIND OF COMMUNICATION?
535
537
ENABLE ADSL DOWNSTREAM RECEIVER
541
543
TRANSMIT AND RECEIV DATA IN ADSL STANDARD PROTOCOL
545
COMMUNICATION CYCLE IS ENDED?
547
DISCONNECT MODEM FROM LINE
525
DESABLE TRANSMITTER, RECEIVERS, STOP CONTROL TONE.
525
ID MATCHED?
511
RECEIVE CF CONTOL TONE DATA
507
TURN-ON UPSTREAM TRANSMITTER
531
TRANSMIT OF ID NUMBER BY CONTROL TONE
539
ENABLE ADSL UPSTREAM RECEIVER
513
ENABLE HALF-DUPLEX PROTOCOL
515
ENABLE ADSL UPSTREAM TRANSMITTER
517
TRANSMITS AND RECEIVE DATA IN HALF-DUPLEX PROTOCOL
519
COMMUNICATION CYCLE IS ENDED?
521

FIG.5



Multipoint NDSL SYSTEM

FIG.6

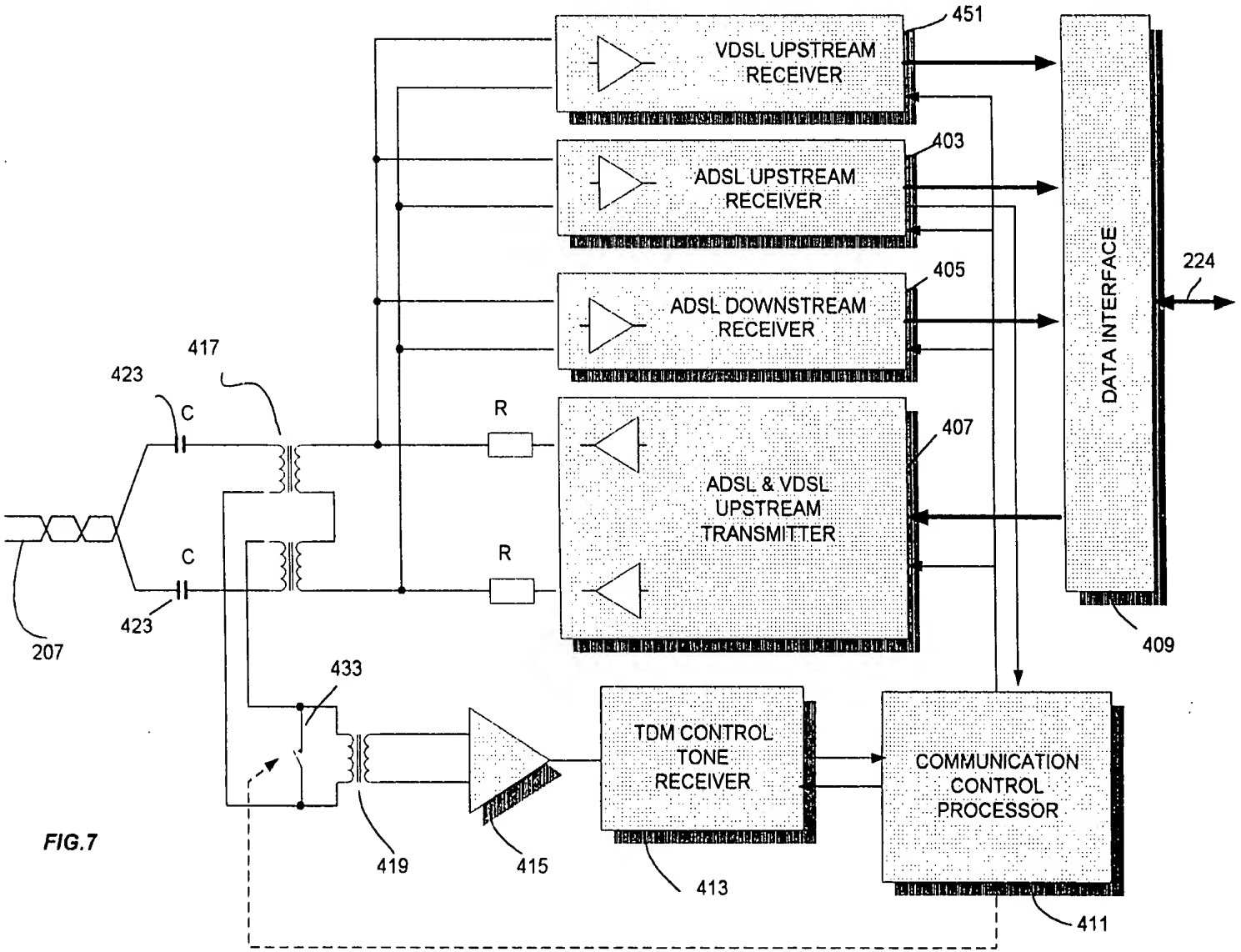
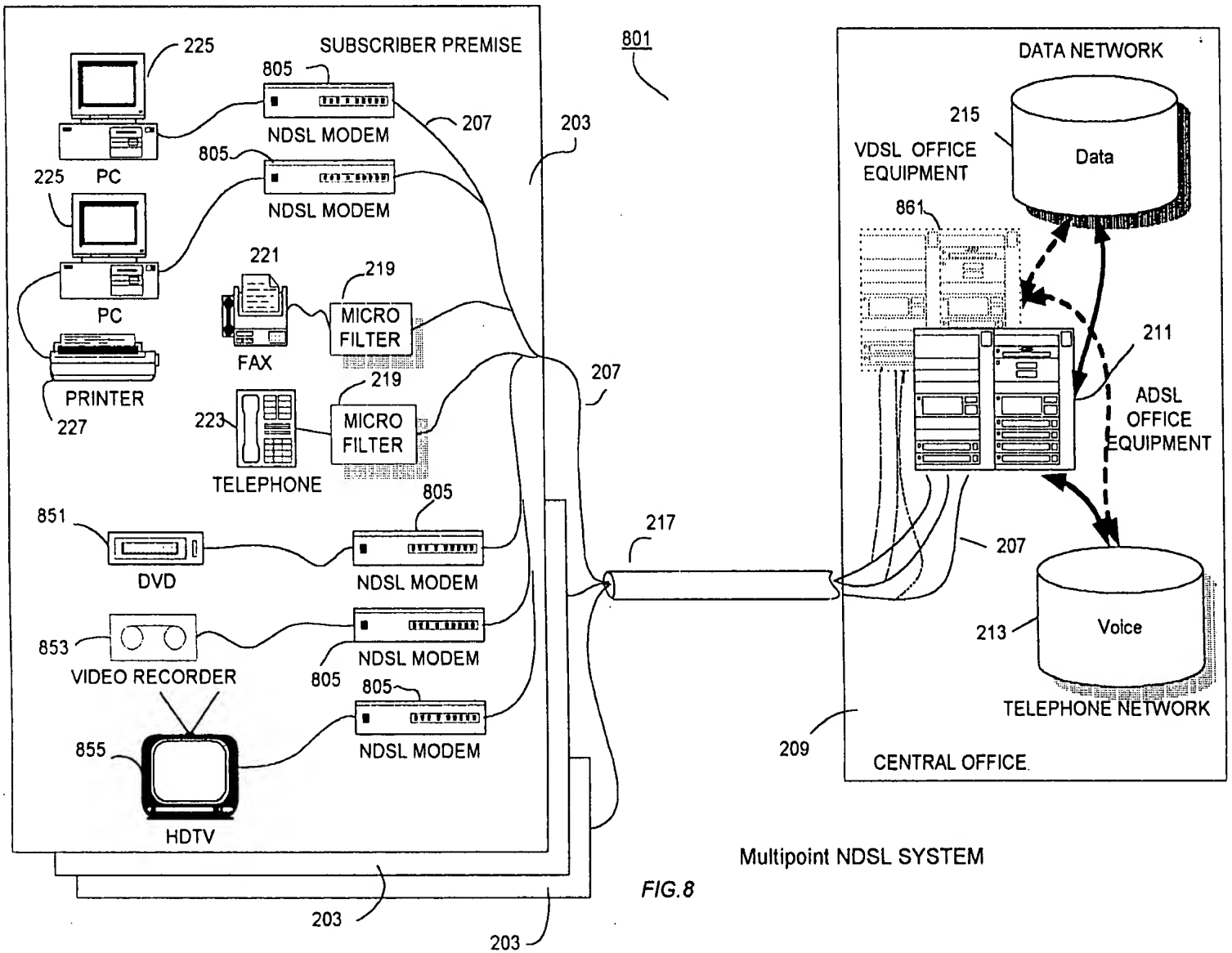

605
VDSL UPSTREAM RECEIVER
451
ADSL UPSTREAM RECEIVER
403
ADSL DOWNSTREAM RECEIVER
405
DATA INTERFACE
224
417
423
C
R
ADSL & VDSL UPSTREAM TRANSMITTER
407
C
R
423
207
409
433
TDM CONTROL TONE RECEIVER
COMMUNICATION CONTROL PROCESSOR
419
415
413
411

FIG.7



Multipoint NDSL SYSTEM

FIG.8

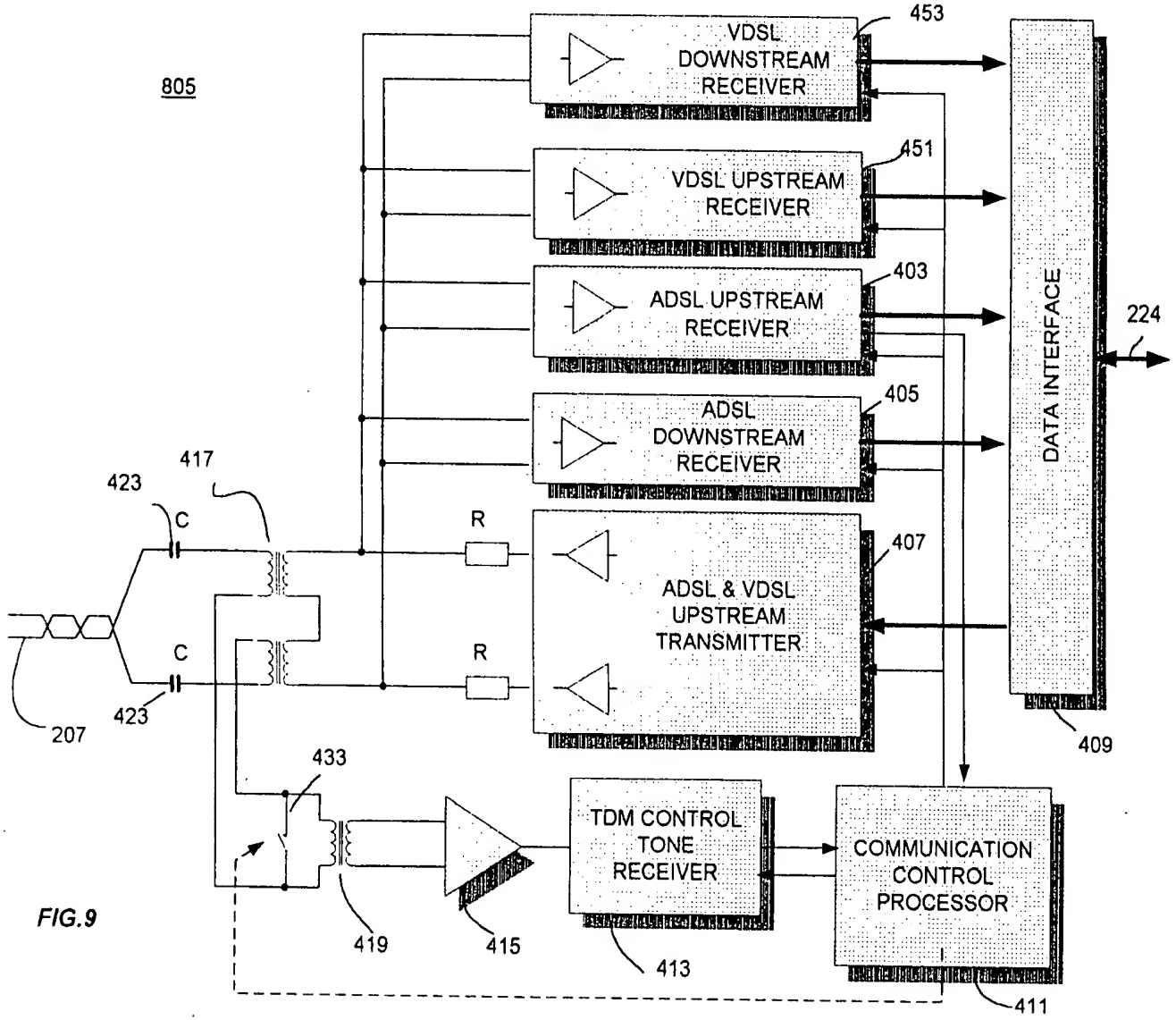
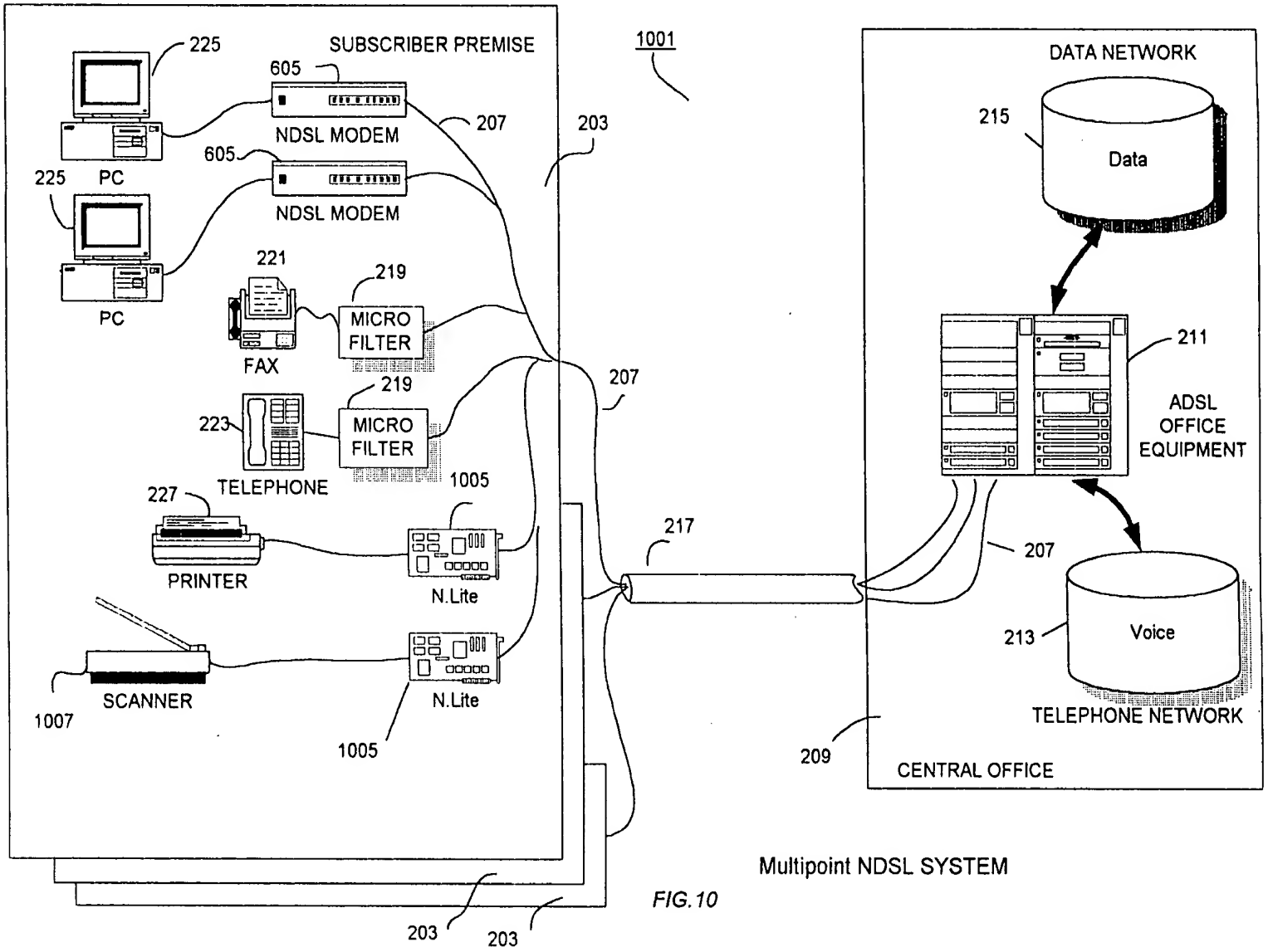

805
VDSL DOWNSTREAM RECEIVER
453
VDSL UPSTREAM RECEIVER
451
ADSL UPSTREAM RECEIVER
403
ADSL DOWNSTREAM RECEIVER
405
ADSL & VDSL UPSTREAM TRANSMITTER
407
DATA INTERFACE
224
409
417
423
C
R
207
433
TDM CONTROL TONE RECEIVER
413
COMMUNICATION CONTROL PROCESSOR
411
419
415

FIG.9



Multipoint NDSL SYSTEM

FIG. 10

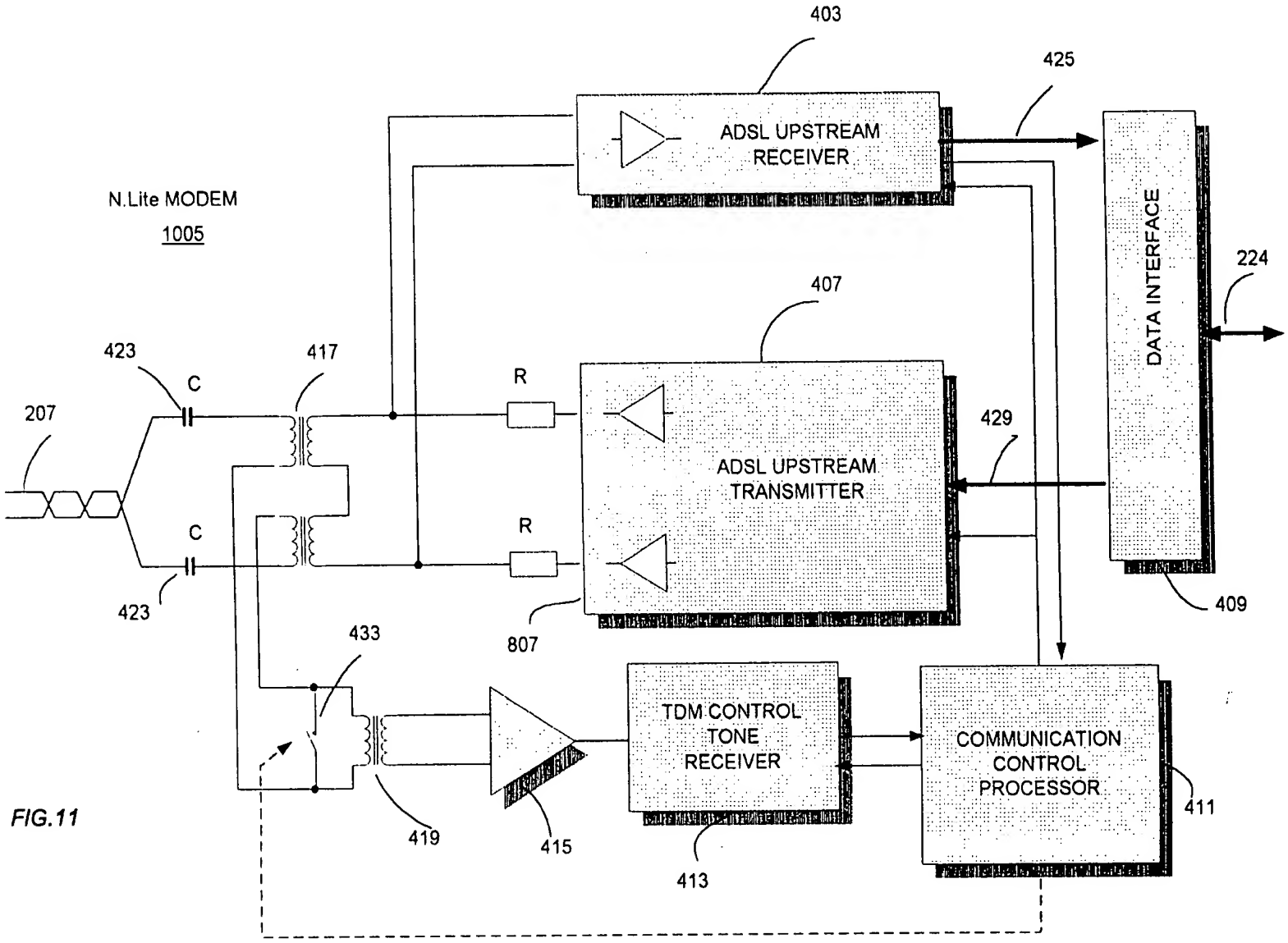
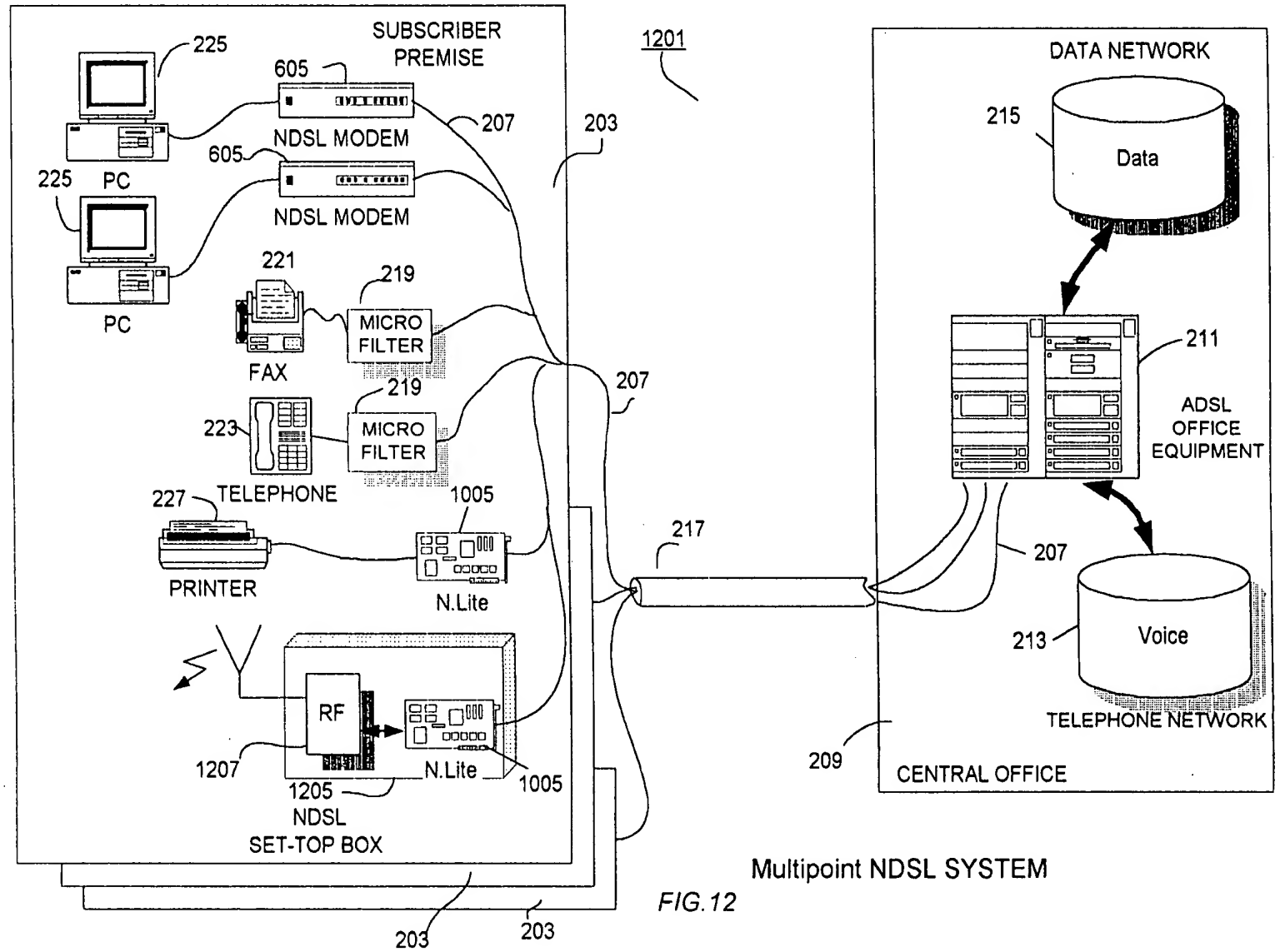

403
425
ADSL UPSTREAM RECEIVER
N.Lite MODEM
1005
DATA INTERFACE
224
407
423
417
C
R
207
429
ADSL UPSTREAM TRANSMITTER
C
R
423
409
807
433
TDM CONTROL TONE RECEIVER
COMMUNICATION CONTROL PROCESSOR
411
419
415
413

FIG.11



Multipoint NDSL SYSTEM

FIG.12